# What is Atmospheric Temperature?

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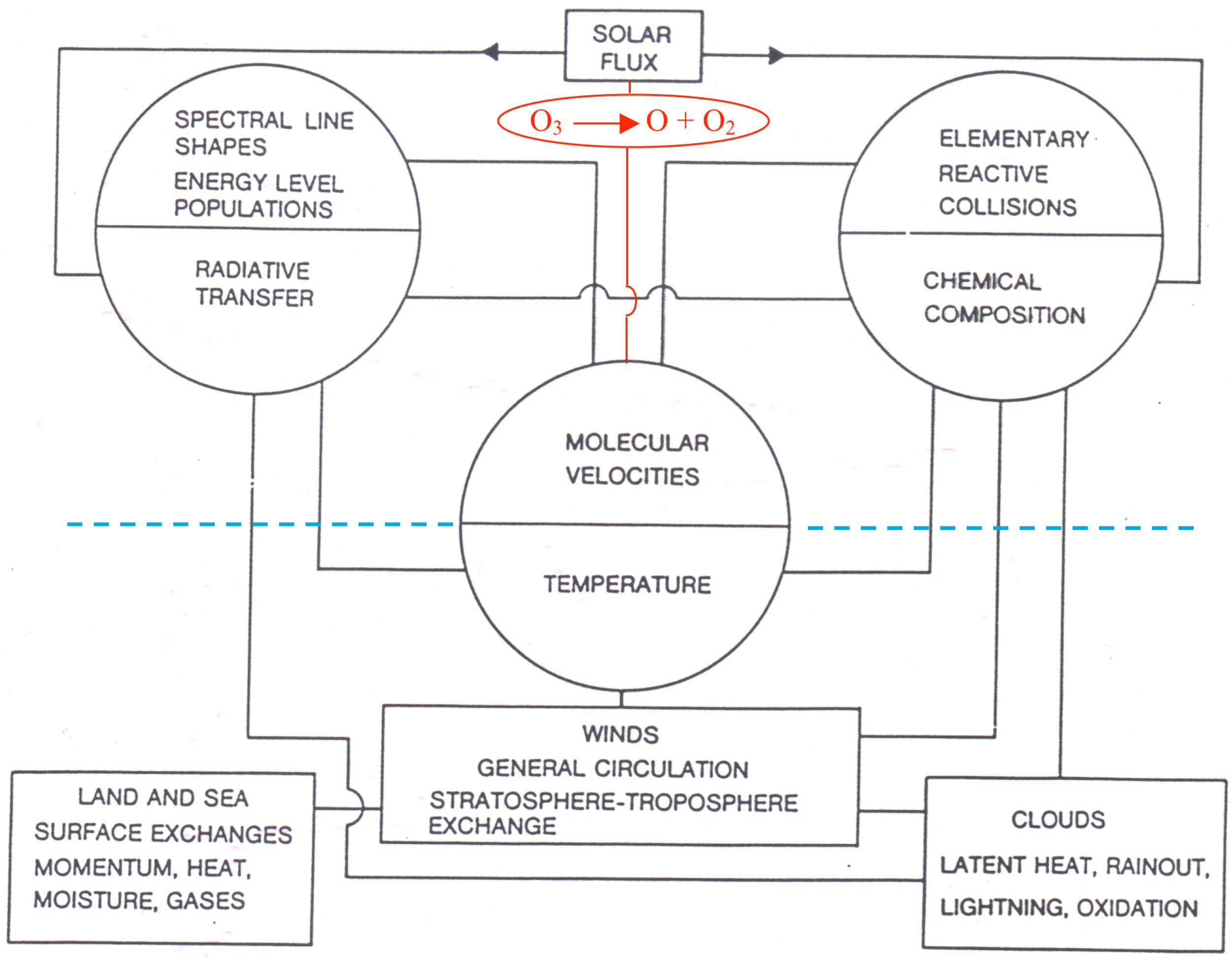
Credits: The Meteorological Chemistry Program people.

# Generalized scale invariance:
# T, winds, humidity, $O_3$

**<u>Platforms:</u>** **ER-2, WB57F, G4 + GPS dropsondes**

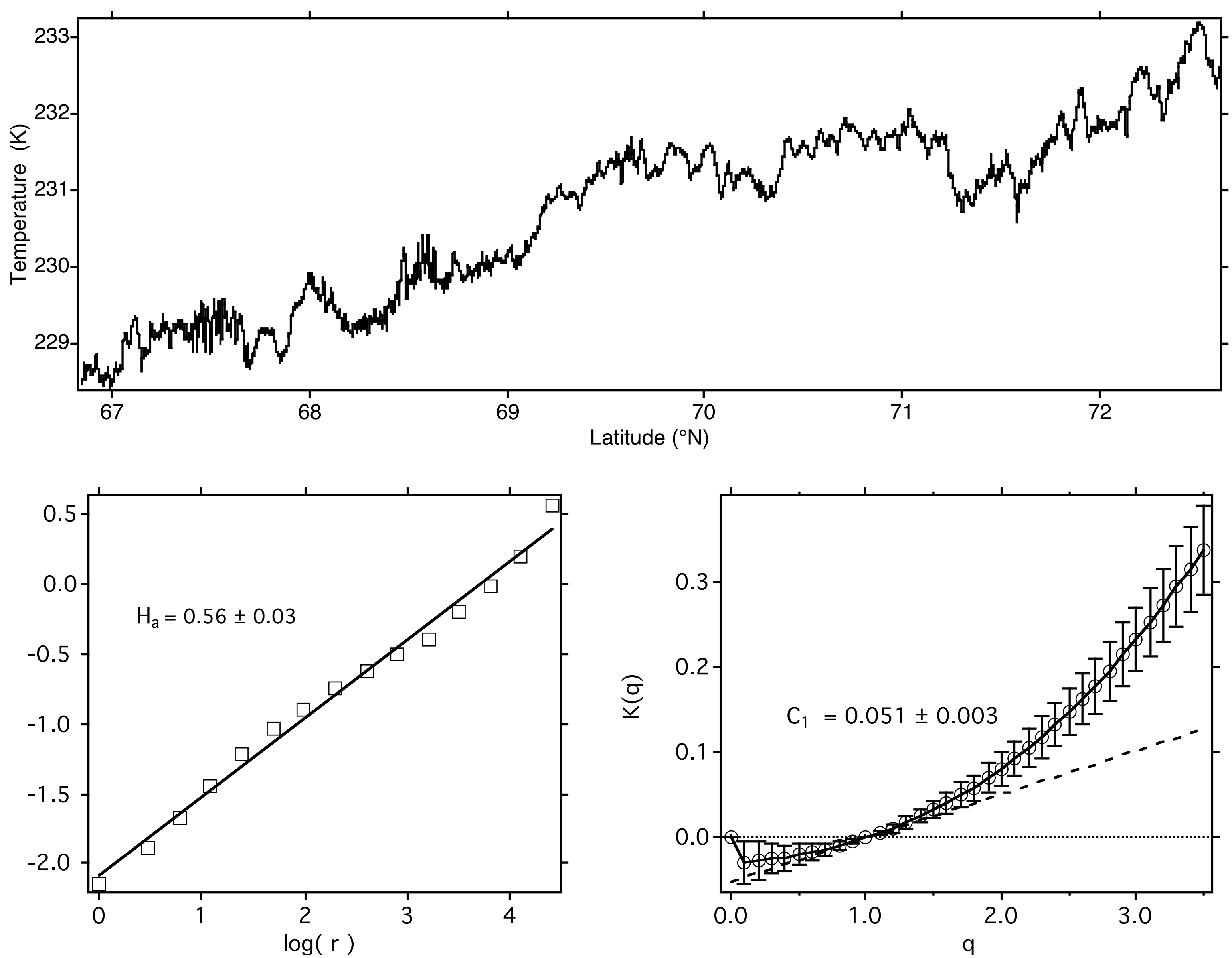
**<u>Frequency:</u>** **Generally 1 - 5 Hz, reported**

**<u>Scales:</u>** **(O) $10^3$ km horizontal, 12 km vertical**

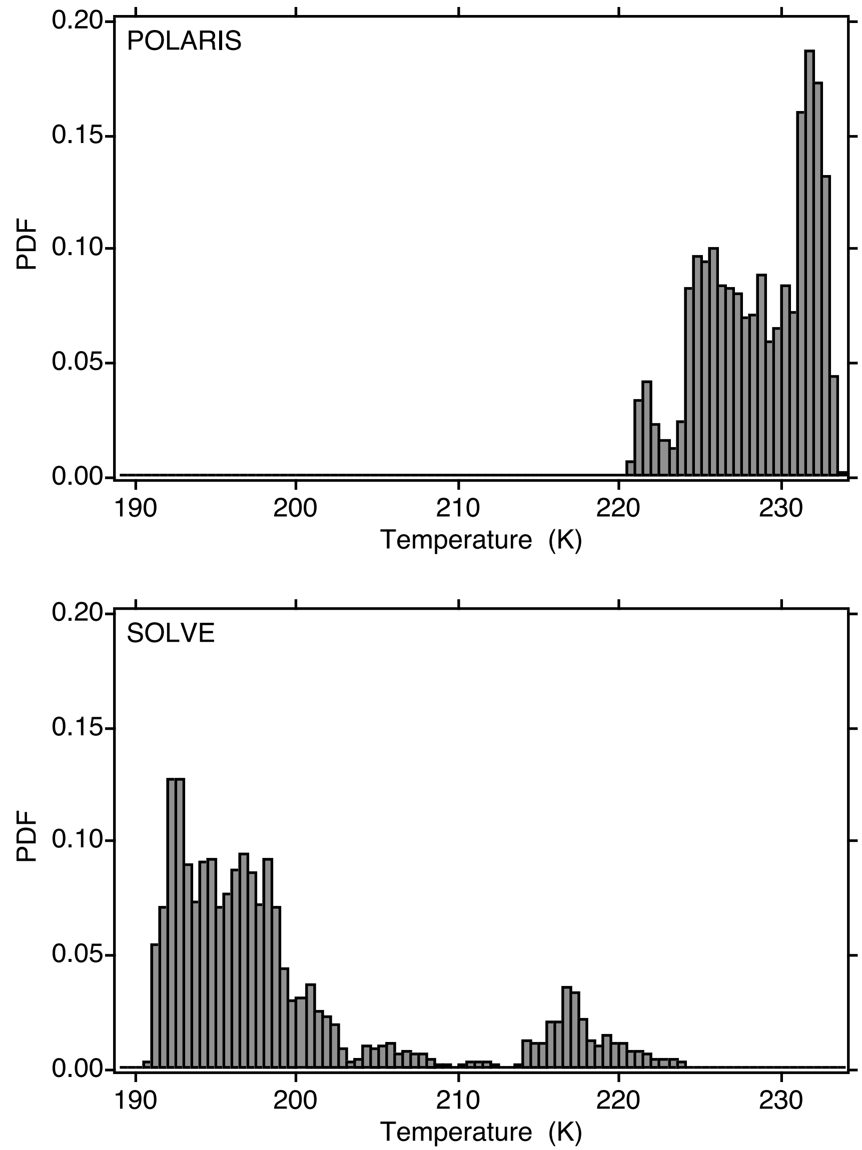

SOLAR FLUX
$O_3 \rightarrow O + O_2$
SPECTRAL LINE SHAPES
ENERGY LEVEL POPULATIONS
RADIATIVE TRANSFER
ELEMENTARY REACTIVE COLLISIONS
CHEMICAL COMPOSITION
MOLECULAR VELOCITIES
TEMPERATURE
WINDS
GENERAL CIRCULATION
STRATOSPHERE-TROPOSPHERE EXCHANGE
LAND AND SEA SURFACE EXCHANGES
MOMENTUM, HEAT, MOISTURE, GASES
CLOUDS
LATENT HEAT, RAINOUT, LIGHTNING, OXIDATION

# 19970506

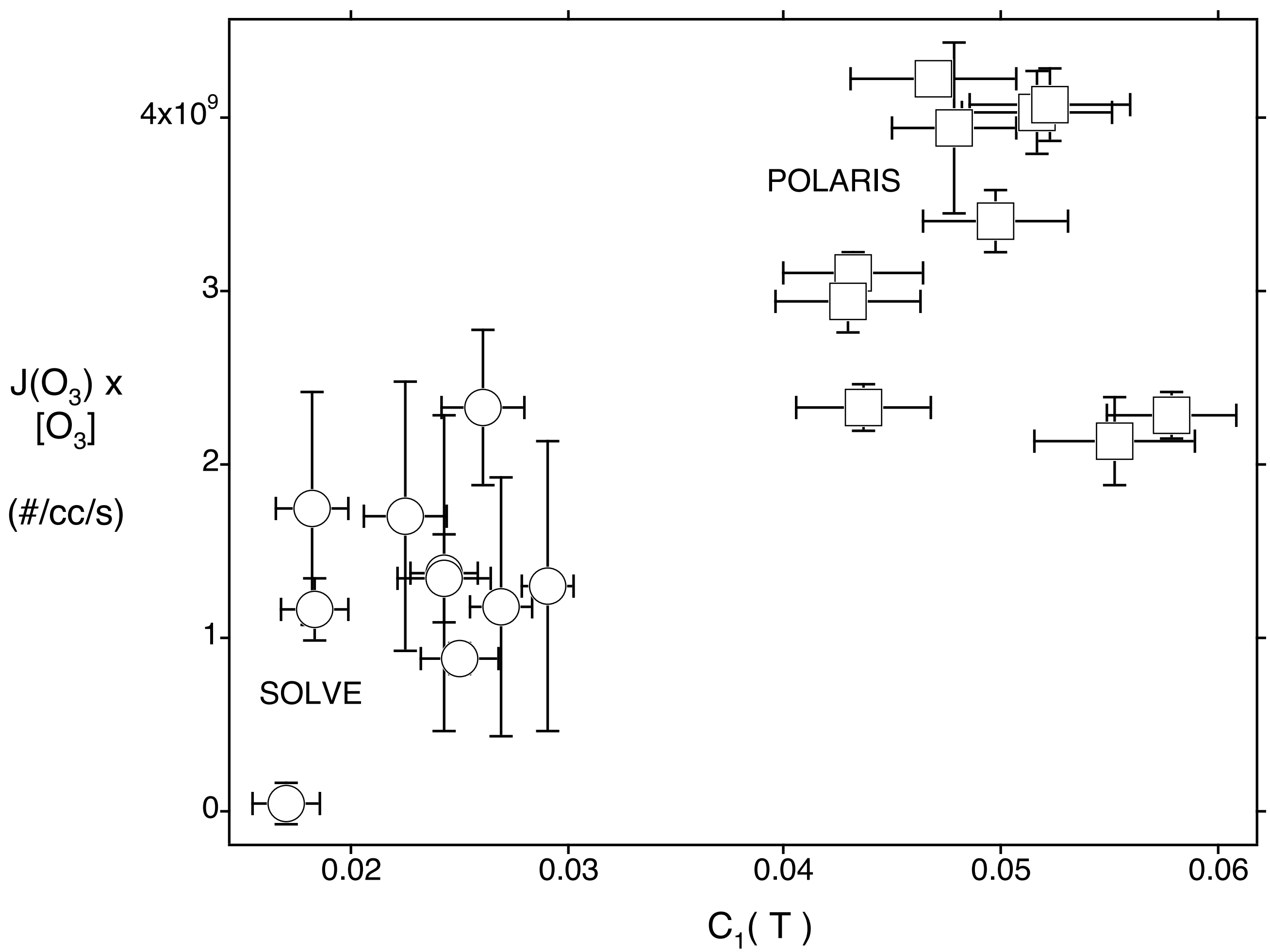
## 5 Hz data



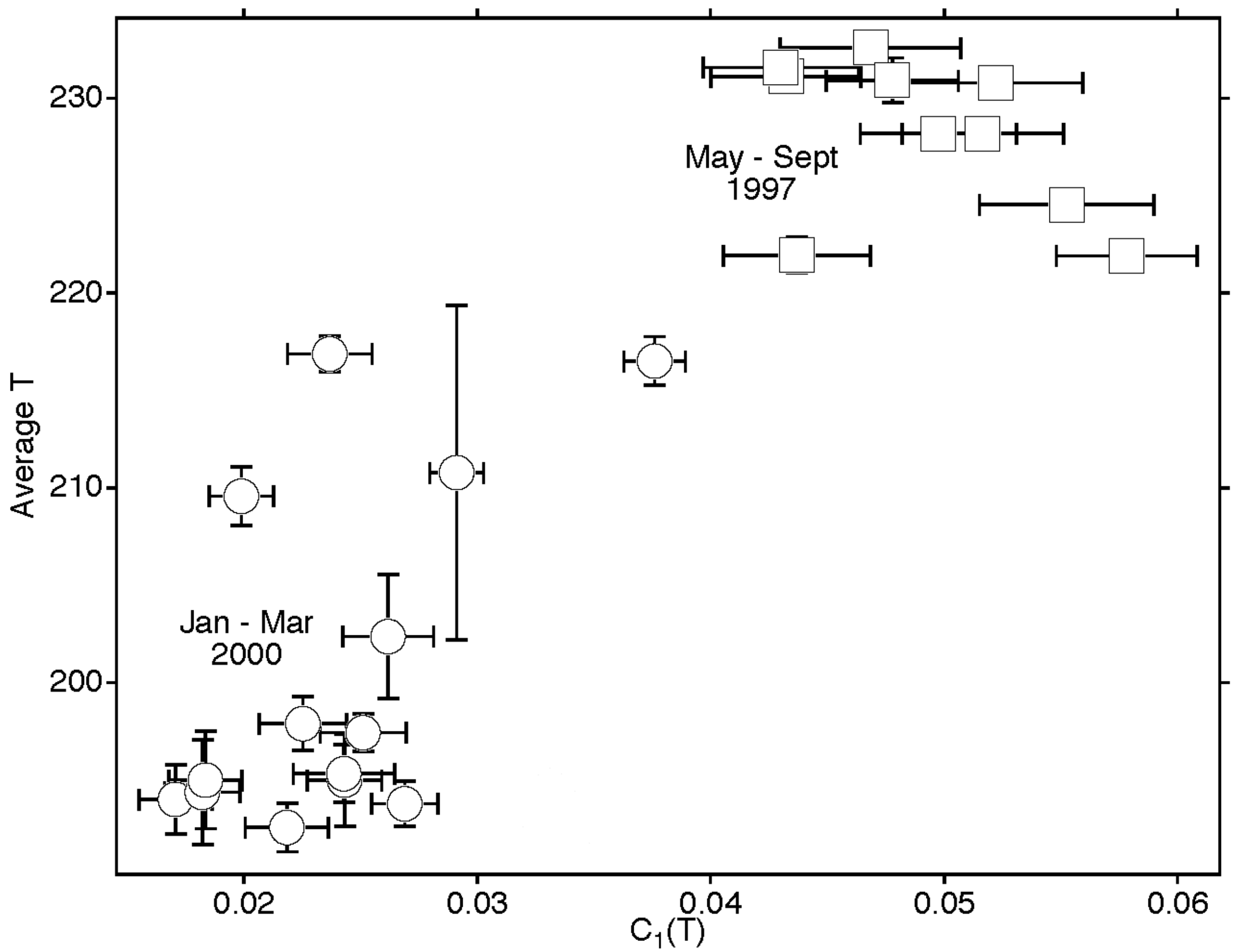
# Temperature PDFs in the Arctic



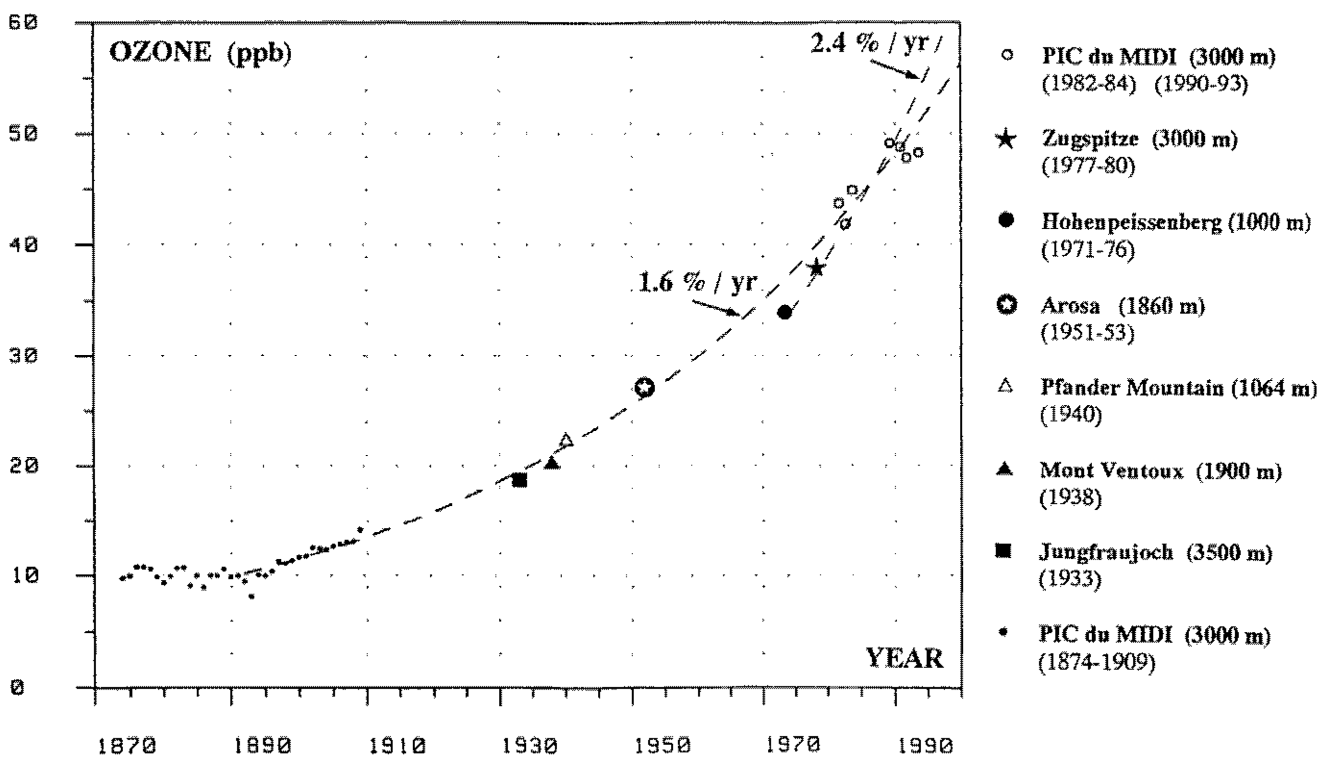
# Ozone Photodissociation Rate vs. Intermittency of Temperature



# Average Temperature vs. Intermittency of Temperature



# Tropospheric Ozone: Marenco et al., *JGR, 99,* 16617 [1994]



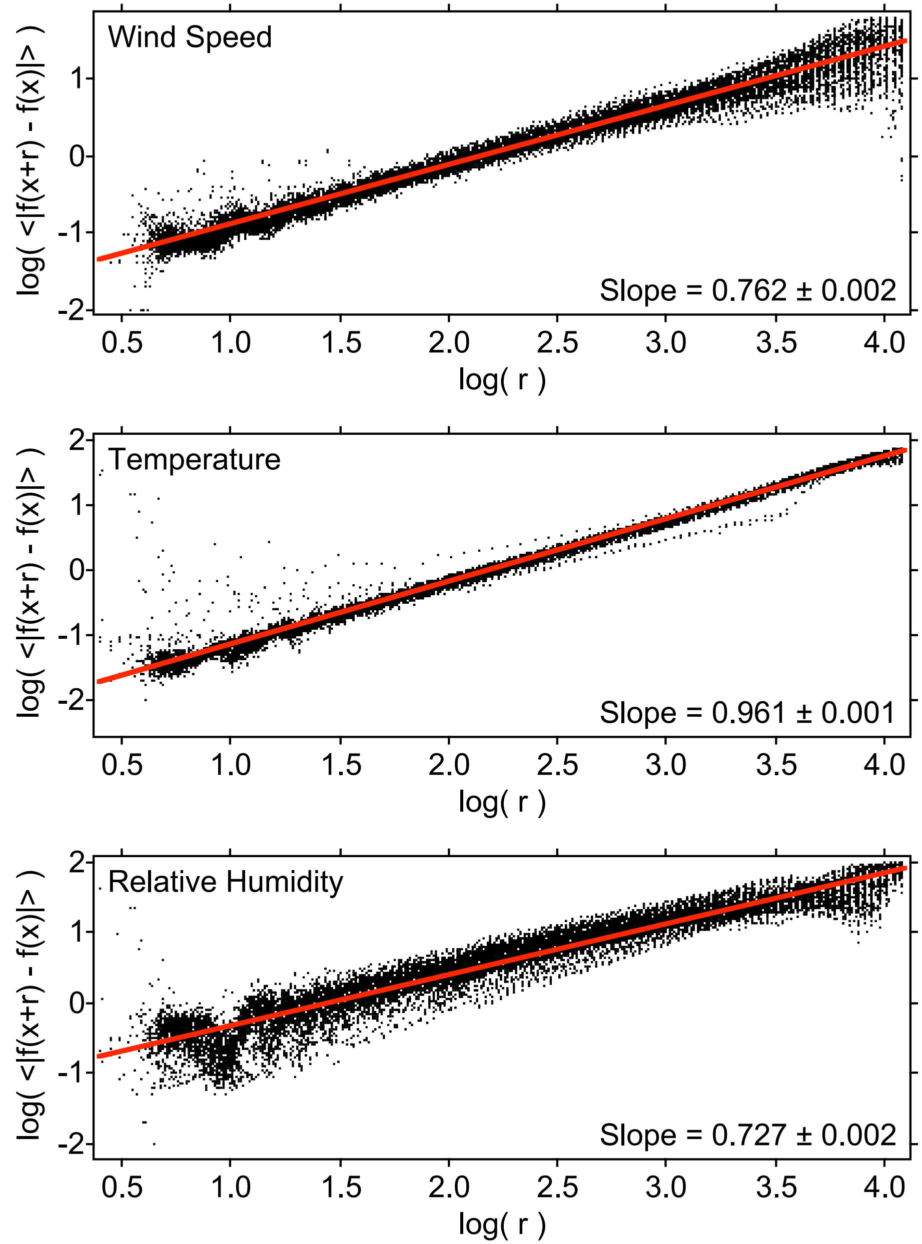
The figures to the right are *composite variograms*, created by overlaying the individual variograms computed for each dropsonde and then fitting a line to the aggregate.

While variograms typically involve variance, we use the first order structure function in order to minimize intermittency corrections and to facilitate comparison with theoretical (dimensional analysis) exponents.

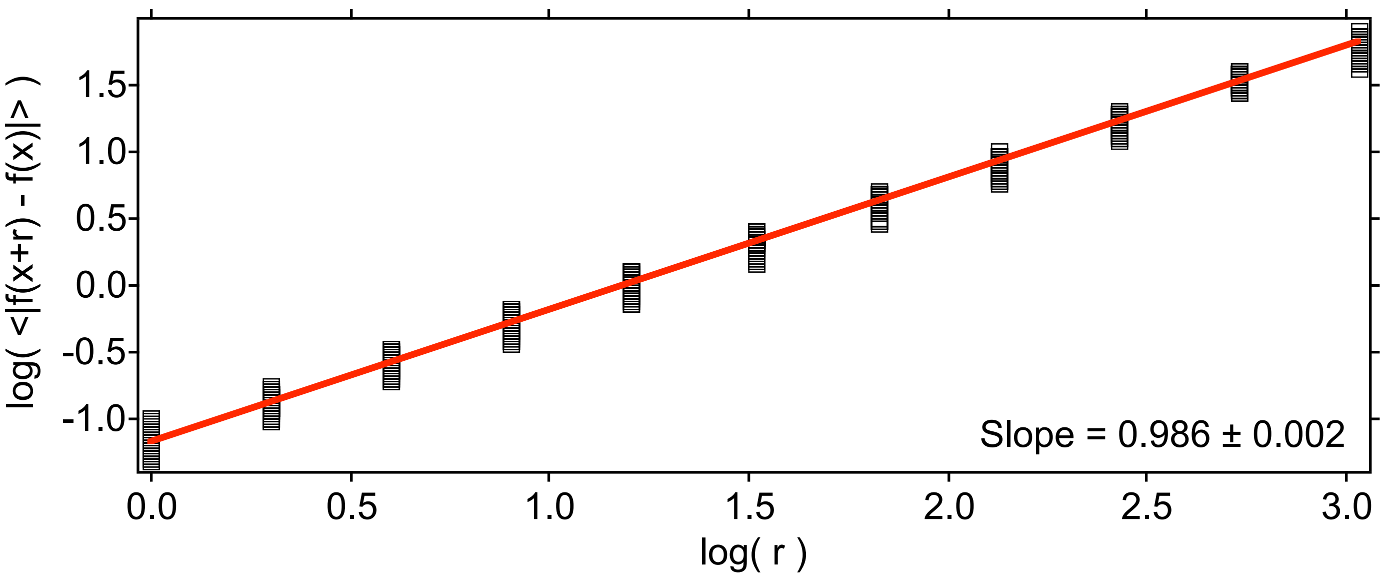
Each individual variogram contained about 100 points, and there were 235 drops that successfully measured wind speed, and 246 that measured temperature and relative humidity. Therefore the lines to the right are each fitting roughly 24,000 points. The errors are 95% confidence intervals.

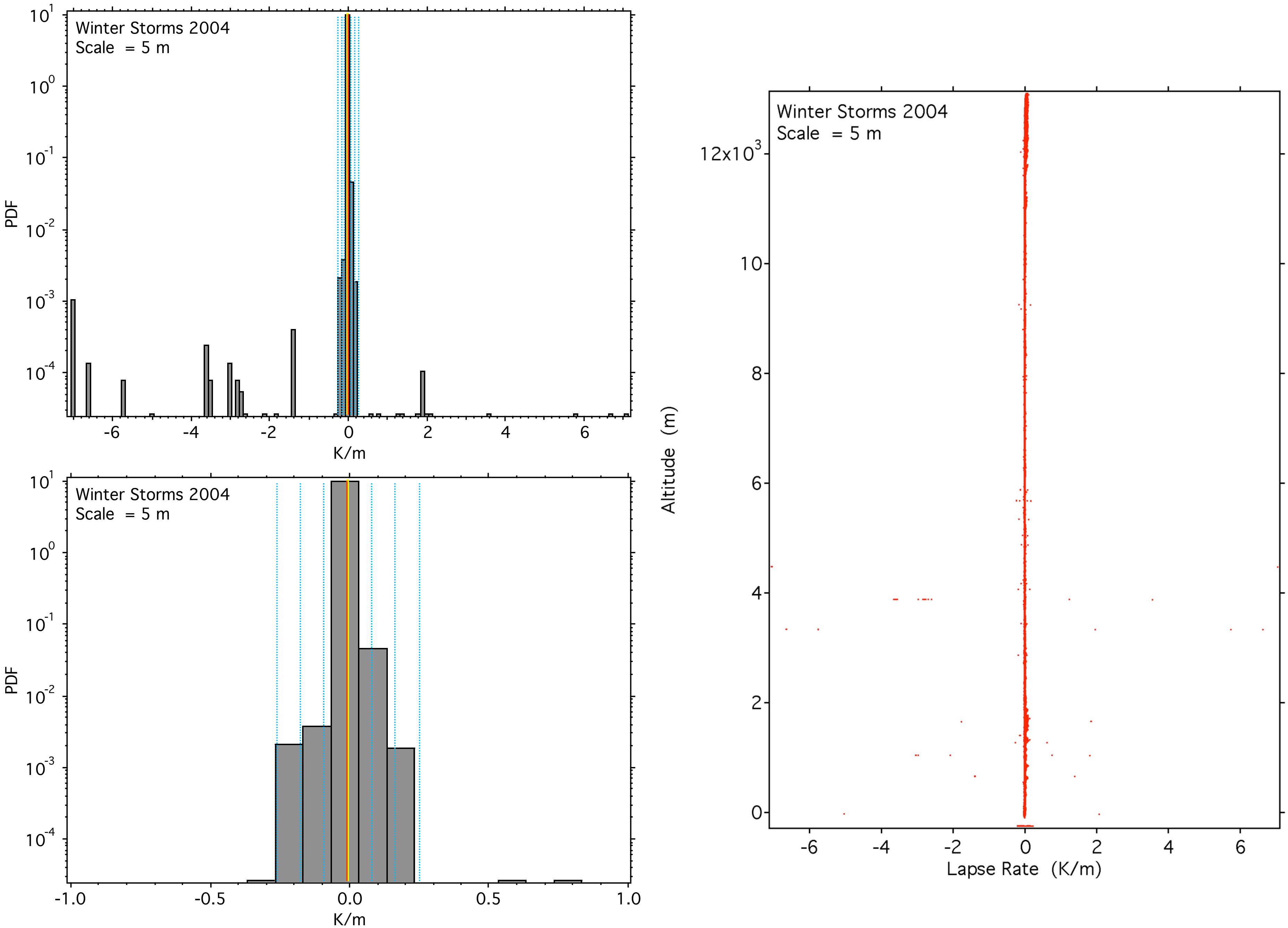
The surprise is that the slope (i.e. $H$) for horizontal wind speed, came out appreciably higher than the Bolgiano-Obukhov theoretical value of 0.6. This indicates smoother than expected horizontal wind speed profiles. It is clear also that temperature behaves differently in the vertical than the other variables.

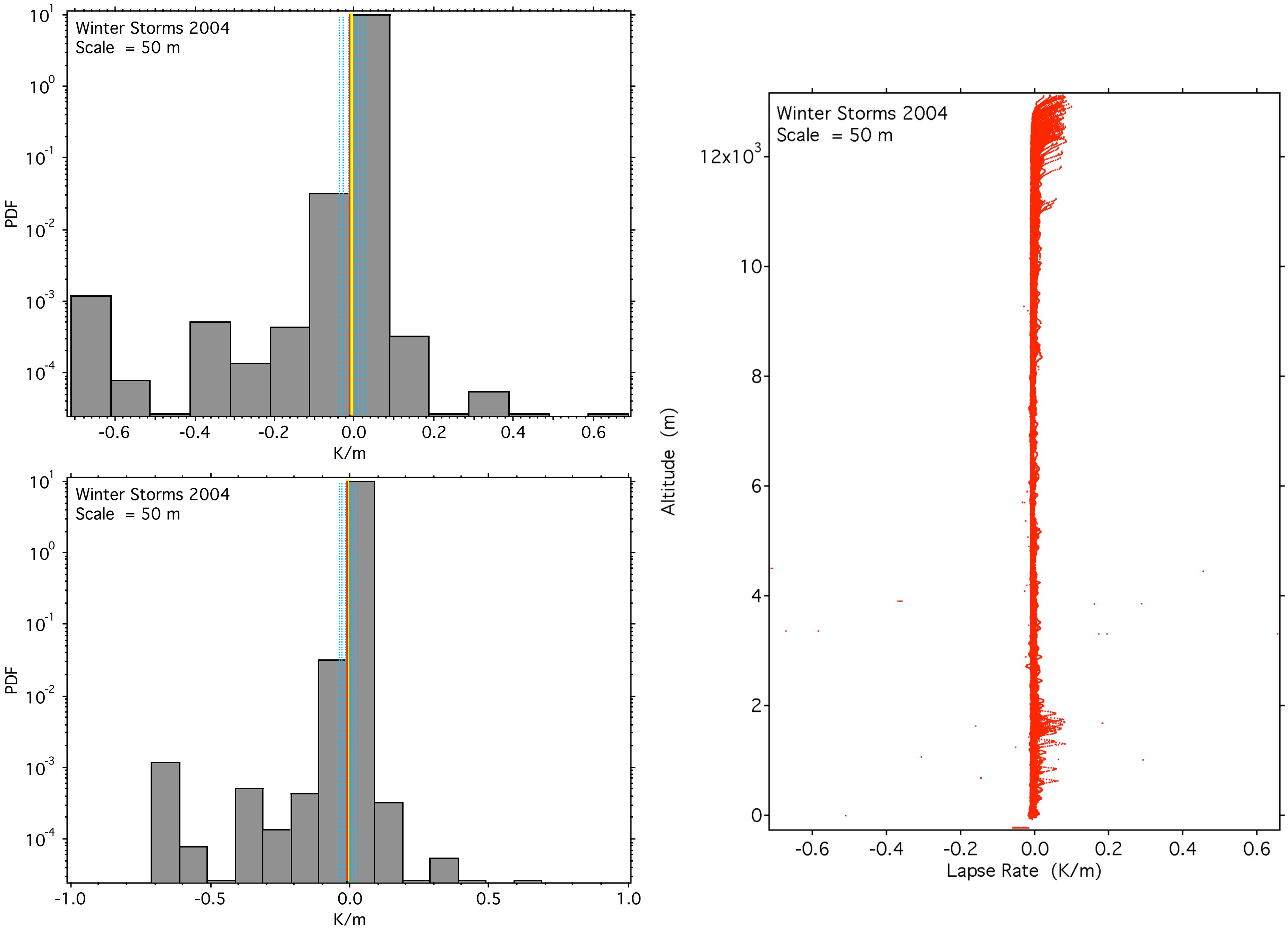
Subsequent spectral analysis has shown that the near-unity value of $H$ for temperature is an artifact of the structure function method, which does not produce a good estimate of $H$ when $H > 1$ or $H < 0$. For the data of 20040229, the spectral method yielded $H \approx 5/4$, again a value unique to temperature.

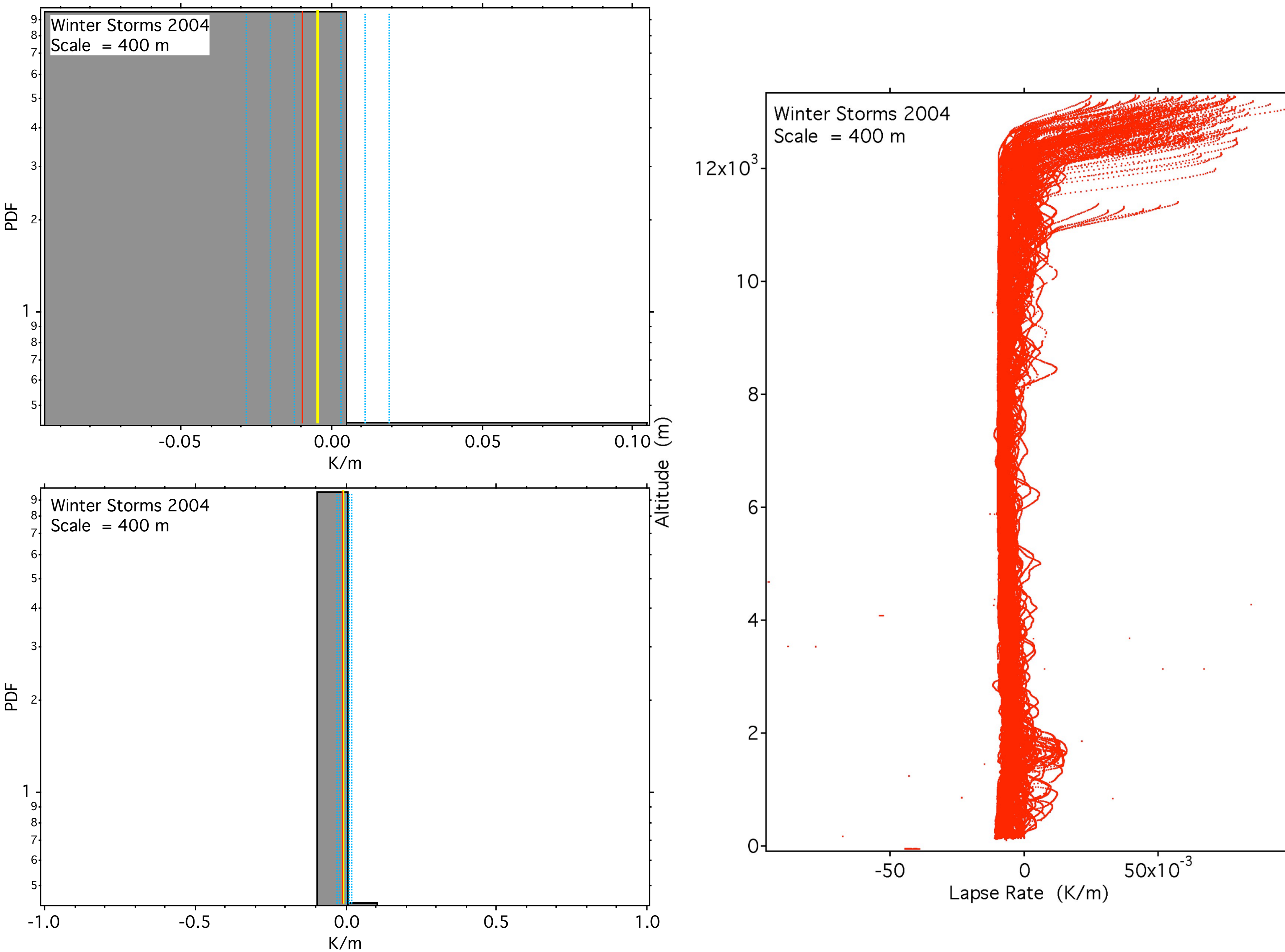


**Winterstorms 2004, Eastern Pacific, GPS Dropsondes:**
**Temperature**
(height-based composite variogram, 246 sondes from 13 km, 15˚- 60˚N, 120˚- 170˚W, 20040129 - 20040314)



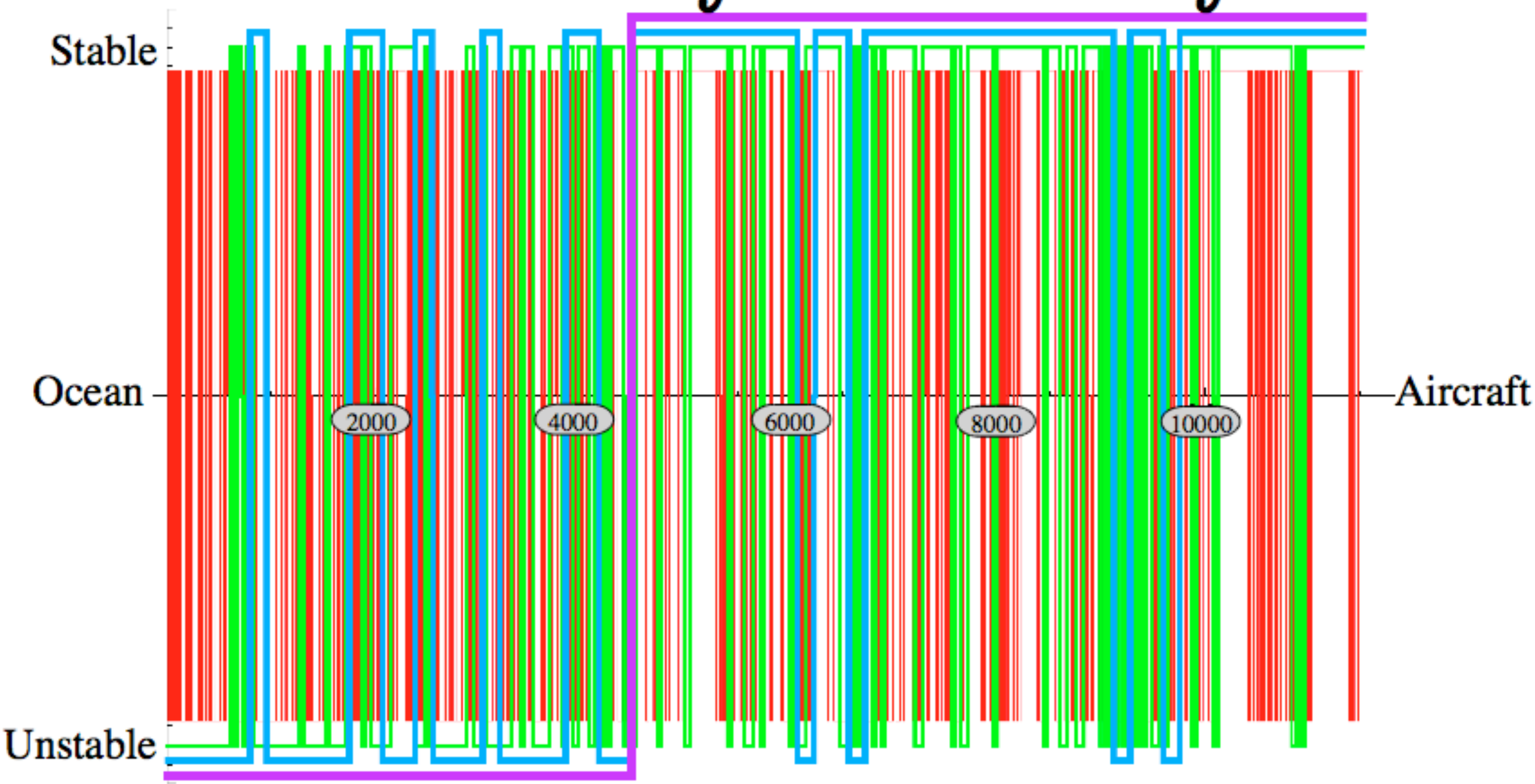

Winter Storms 2004
Scale = 5 m
PDF
K/m
Altitude (m)
Lapse Rate (K/m)


Winter Storms 2004
Scale = 50 m
PDF
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
K/m
Winter Storms 2004
Scale = 50 m
PDF
-1.0
-0.5
0.0
0.5
1.0
K/m
Winter Storms 2004
Scale = 50 m
Altitude (m)
$12x10^{3}$
10
8
6
4
2
0
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
Lapse Rate (K/m)



Winter Storms 2004
Scale = 400 m
PDF
K/m
-0.05
0.00
0.05
0.10
Winter Storms 2004
Scale = 400 m
PDF
K/m
-1.0
-0.5
0.0
0.5
1.0
Winter Storms 2004
Scale = 400 m
Altitude (m)
$12x10^3$
10
8
6
4
2
0
Lapse Rate (K/m)
-50
0
$50x10^{-3}$

# Richardson Dynamic Stability




This figure shows (for sonde #2 of 20040229), at higher and higher resolution, the Richardson dynamic stability criterion for layers 640 m, 160 m, 40 m, and 5 m thick. It shows that within each stable layer, there are unstable layers, within which is embedded another stable layer, etc. The fractal pattern has fractal correlation codimension 0.09, i.e. a dimension of 1 - 0.09 = 0.91, so that the transitions are sparse but not too sparse. It would seem that the notion of a homogeneous stable layer is quite academic!

**<u>Temperature</u>: no LTE, no Gaussians, different scaling.**

**<u>Scaling range</u>: extend in both the horizontal and vertical.**

**Need both improved standard and new instruments.**

**Suggest selected water vapor line, fn(P,T).**

**Essential to improve S:N ratio, frequency and eliminate data gaps.**

**Very careful siting of static pressure and temperature ports on aircraft.**

**Record autopilot inputs and outputs.**

END